

LETTERS TO THE EDITOR.

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The Problem of the Random Walk.

THIS problem, proposed by Prof. Karl Pearson in the current number of NATURE, is the same as that of the composition of n iso-periodic vibrations of unit amplitude and of phases distributed at random, considered in *Phil. Mag.*, x., p. 73, 1880; xlvi., p. 246, 1899; ("Scientific Papers," i., p. 491, iv., p. 370). If n be very great, the probability sought is

$$\frac{2}{n} e^{-r^2/n} r dr.$$

Probably methods similar to those employed in the papers referred to would avail for the development of an approximate expression applicable when n is only moderately great.

RAYLEIGH.

Terling Place, July 29.

The Causation of Variations.

IT is sometimes said that natural selection has ceased as regards civilised man; but very clearly this is an error. All civilised and most savage races are very stringently selected by various forms of zymotic disease. Thus in England practically everyone is brought into contact with the organisms which give rise to tuberculosis, measles, and whooping-cough; those individuals who are the most resistant to the organisms repel infection (*i.e.* do not fall ill), the less resistant suffer illness but survive, the least resistant perish. Abroad, malaria, dysentery, and many other complaints play a similar rôle. Probably no one is absolutely immune to any disease; but since illness only follows invasion of the tissues by a sufficient number of the microbes (the sufficiency of the number varying with the individual attacked), and since the microbes are more abundant in some localities than in others, the stringency of selection as regards any disease is greater in some places than elsewhere. For example, selection by tuberculosis is more stringent in the slums of cities than in the country. It should be noted, also, that resisting power against any one disease does not imply resisting power against any other; thus an individual innately strong against measles is not necessarily strong against tuberculosis. The result of all this elimination by diseases demonstrates the action of natural selection very beautifully. Every race is resistant to every disease strictly in proportion to its past experience of it. Thus Englishmen who have suffered much from tuberculosis are more resistant to it than West African Negroes who have suffered less, and much more resistant than Polynesians who have had no previous experience of it; that is, as a rule, Englishmen, under given conditions, contract the disease less readily, or if infected recover more frequently, or if they perish do so after a more prolonged resistance than Negroes and Polynesians. Negroes, on the other hand, as South American plantation experience proves, are more resistant to malaria than Asiatic coolies, who in turn are more resistant than Englishmen and Polynesians.

Against some diseases (*e.g.* tuberculosis) no immunity can be acquired, that is, experience of the disease confers no increase of resisting power, the disease pursuing a course of indefinite length. Against other diseases (*e.g.* measles) immunity may be acquired, that is, experience of the disease, if not fatal, confers after a definite time a more or less permanent immunity on the sufferer. In the former case the survivors are mainly those who have an inborn power of resisting infection; in the latter they are those who have an inborn power of recovering from infection. Evolution has proceeded on these lines. Thus Englishmen are less readily infected with tuberculosis than Polynesians, but nearly all Englishmen, like Polynesians, readily take measles, though a much greater proportion of them survive and acquire

immunity. Lastly, in relation to such very "mild" diseases as chicken-pox, which render the individual very ill while they last, but cause hardly any elimination, no race appears to have undergone any change; for instance, no race, apparently, is more resistant to chicken-pox than any other race.

The pathogenetic organisms of all prevalent human diseases are more or less entirely parasitic on man. Most of them, therefore, flourish best in crowded populations, where they can pass readily from one susceptible individual to another. Thus tuberculosis is most prevalent in the slums of great cities. An important exception is malaria, the parasites of which require special conditions, and which, therefore, is more prevalent in the open country than in towns. The inhabitants of the eastern hemisphere have been afflicted by a multitude of zymotic diseases for thousands of years. Of old, with the increase of population, the conditions slowly became worse, the stringency of selection became greater, and the human races underwent continual evolution. But before the voyage of Columbus zymotic disease, with the exception of malaria, appears to have been almost, if not quite, unknown in the New World. We have fairly definite accounts of the first introduction of most Old World diseases to this and that aboriginal race, and of the frightful destruction of life that followed, the principal agent of elimination being tuberculosis. With their diseases the European immigrants introduced modern civilised conditions of life, especially churches, schools, and other enclosed spaces in which the natives, crowded together, conveyed infection to one another, and clothes, which acted as a deterrent to cleanliness, and which, besides, harboured the microbes of disease better than the naked skin. As a consequence, except when protected by malaria in extensive forests or when dwelling remote in unsettled regions, the natives rapidly perished. It is a significant fact that, whereas in Asia and Africa every town inhabited by Europeans has its native quarter, no European town in the temperate parts of the western hemisphere (*i.e.* where tuberculosis is most rife) has its native quarter. Published health statistics demonstrate quite definitely that the abnormally high mortality of the natives is caused by introduced diseases. Since civilisation implies a dense and settled population, it follows that no race can now achieve civilisation that has not undergone evolution against tuberculosis and kindred diseases. The case of the Negroes is interesting. In Africa they had undergone some evolution against tuberculosis. In America, when they were first taken to it, the disease prevailed to a comparatively slight extent, especially amongst the agricultural population; but the conditions slowly became worse, and the descendants of the early slaves underwent concurrent evolution. To-day they are able to persist in the northern cities, though their death-rate there is still abnormally high. But though a constant stream of Negro slaves and soldiers (*e.g.* in Ceylon) was poured for centuries into parts of Europe and Africa, they have left no trace on the population. All perished in a few generations, the elimination being so stringent as to cause extinction, not evolution. It is tolerably certain that a fresh immigration of African Negroes to America would end as disastrously.

These facts appear to establish conclusively two truths, first that evolution is due solely to natural selection, and second that variations, except, perhaps, in rare instances, are not due to the direct action of the environment on the germ-plasm, but are "spontaneous." The Lamarckian doctrine is quite out of court. If ever acquirements are transmitted, it should be in the case of the profound and lasting changes affecting the whole body which result from disease; but in no instance is the effect produced by any disease on the race similar to that produced by it on the individual. Thus tuberculosis injures the individual but confers resisting power on the race; measles confers immunity on the individual, but none on the race. Were the Lamarckian doctrine true, man could not persist on the earth. Presumably this is true of all other species, since probably all organisms are subjected to causes of slow deterioration similar to disease. If ever external agencies acting directly on the germ-plasm alter its composition and so cause variations (of any sort) in offspring,

it should be, when germ-cells are literally soaked for prolonged periods in some virulent toxin such as that of malaria. Presumably the effect should be a harmful one, and it should act in much the same way on the germ-cells of one individual as on those of another; the race should, therefore, by the accumulation of injury, steadily deteriorate until it becomes extinct; but in no case is this observable. A disease may exterminate a susceptible race, but there is no evidence that it is ever a cause of racial degeneration. The same is true of races exposed to the complex of harmful agencies which surround urban life—filth, over-crowding, lack of light and air, of suitable food and exercise, and so forth. None of the races which have been longest and most exposed to them have become degenerate—for example, the Chinese, the Hindoos, the Egyptians, and the inhabitants of Europe. These races have merely become permanently resistant, preeminently capable of an urban existence. Red Indians and Polynesians perish *en masse* under such conditions. There is not an iota of evidence which demonstrates that the children of peasants if removed at birth to the city would on the average be better developed than the descendants of a line of slum dwellers. The legend that urban families tend to become extinct within four generations is founded on the fact that migration and inter-marriage between town and country is so great that no families purely urban for four generations exist.

Bearing in mind the fact that races grow resistant to all diseases to which they are exposed, the only conceivable non-miraculous cause of evolution (*i.e.* adaptation) is natural selection. But natural selection cannot act when any agency (*e.g.* malaria) causes a drift in a particular direction, *i.e.* when all variations are unfavourable, and offspring tend always to fall below the parental mean. Students of evolution have generally thought of elimination in terms of sudden death as by the agency of carnivorous animals, when the individual who perishes dies in the fulness of his strength, and the individual who survives is strengthened rather than weakened by his efforts to evade destruction. It is clear, however, when considering causes of slow deterioration, which affect practically the whole population during youth, that the doctrine of natural selection is incompatible with the doctrine that variations are caused by the direct action of the environment. It is clear also that natural selection itself must always tend to establish a high degree of insusceptibility to direct action. A greater or lesser degree of susceptibility of the germ-plasm is itself a variation. The more susceptible type of germ-plasm tends continually to be eliminated, and a high degree of insusceptibility established. This is not the same thing as saying that the germ-cells are inviolable and cannot be injured. It is only implied that their "hereditary tendencies" are implanted in them almost as firmly as life. The behaviour of somatic cells confirms this view. A gland, for example, may be diseased for twenty years, yet on recovery we do not find a new type of cells; on the contrary, the descendant cells are quite of the old type.

No doubt many instances of the alleged direct action of the environment on the germ-plasm have been recorded. Thus medical men have published statistics to prove that the children of alcoholics and consumptives tend to be insane; but as a rule this evidence is inconclusive in that it fails to demonstrate that the proportion of insane is higher among them than among the offspring of normal parents. Numerous other factors of error, also, are not taken into account. In some cases published by biologists acquirements do not seem to have been clearly differentiated from variations. Thus in the well known case of Weismann's butterflies ("Germ-Plasm," p. 399) we are not told that the darkening of colour produced by a higher temperature was accentuated during subsequent generations by similar treatment, nor that the darkened individuals reproduced their like in the absence of the high temperature. *A priori* there is no apparent reason why acquirements should not be made in the germ-cell stage of the individual as well as during subsequent stages of development. In other cases, as when plants have been removed to a new environment, the effects of a different survival of the fit have not apparently been taken into account. It must be remembered that natural selection not only adapts organisms to changing environments, but keeps

them stable in stable environments, and so eliminates the variations which appear in the new surroundings.

It is not necessary, of course, to believe that variations are never caused by the direct action of the environment. Presumably the insusceptibility of the germ-plasm is due to evolution, and evolution is never perfect. It is only necessary to believe that in circumstances normal to the species the insusceptibility is so high that the amount of variations produced by the direct action of the environment is so minute as to be negligible, *i.e.* not a cause of racial change. It is possible that when species are removed to very new environments (*e.g.* European dogs to India or horses to the Falkland Islands) the germ-plasm is sometimes changed by conditions to which natural selection has not rendered it highly insusceptible; but the deterioration which is said to result in such cases is clear evidence of the necessity of this insusceptibility. If it be not established the species must perish.

G. ARCHDALL REID.

The Empire and University Life.

IN your issue of July 6 your powerful advocacy of a higher and broader education in our great universities casts me back in memory to more than fifty years ago, when I first was transported with delight at F. von Schlegel's great generalisation of the unity of the Indo-European family of languages. I was then astounded that Oxford and Cambridge, through so many centuries, had not seen this great truth.

The theological and catastrophic method had darkened the mental vision of both Oxford and Cambridge; even the mighty Whewell, in 1846, wrote from Cambridge:—"Not only, then, is the doctrine of the transmutation of species in itself disproved by the best physiological reasonings, but the additional assumptions which are requisite to enable its advocates to apply it to the explanation of the Geological and other phenomena of the earth, are altogether gratuitous and fantastical."

From Oxford, her powerful son, the G.O.M., could not rise to feel that the first chapter of Genesis was a sublime poem; he could not rise to feel the truth of the most elementary facts of geology; so enchain'd was his mind that he could not feel the poetry and spirituality of the "Sacred Books of the East"; the Hindu philosophers and poets give their ideal demi-gods a vast age, even to 900,000 years; but they know that it is poetry and ideal. But Oxford's greatest son could not rise to such elementary generalisation; he saw the great doctrine of "continuity" no wider than the concrete mythology of the Hebrews—he believed in the literal and personal Methuselah of 969 years!

These modern examples of bad method are but glaring "instances" of the general bad method which permeates society, permeates the professions, above all, the professions of theology and medicine.

The Method (see Coleridge) of Oxford and Cambridge in its influence on its sons always reminds me of the words of Sismondi¹; writing of the "erudition" of the Greeks of the tenth century, Sismondi says:—"Few (of their) books seem better constructed to show the vanity of erudition, and to place in strong contrast a vast extent of knowledge, with a total incapacity of deriving any useful results from it." "Were it necessary to choose between the whole experience which has been acquired and collected from the beginning of time, the whole rich store of human wisdom, and the mere unschooled activity of the human mind, the latter ought, without hesitation, to be preferred. This is the precious and living germ which we ought to watch over, to foster, to guard from every blight. This alone, if it remain uninjured, will repair all losses; while, on the contrary, mere literary wealth will not preserve one faculty, nor sustain one virtue."

We do not want revolution, but an active evolution, both at Oxford and Cambridge, based, as Coleridge said, on the "historic sense."

May I add my personal experience, that I have been able to converse in a more genial, enlightened spirit and

¹ "History of the Inductive Sciences," 3rd ed., 1857, vol. iii. p. 481.

² "Fall of the Roman Empire," vol. ii., pp. 258, 261 (1834).